HYDRO FA P2.7 WATER USE OF TWO DOMINANT RIPARIAN VEGETATION COMMUNITIES IN SOUTHEASTERN ARIZONA

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1. INTRODUCTION

For many of the human settlements in the Southwest, water from regional aquifers has become the largest single source of fresh water for human communities. Without this source of groundwater, the further development and perhaps even the continuation of these communities would not be possible. This reliance has led to a large effort to further our understanding of the water balance of these large regional groundwater systems.

In the basin and range physiographic province of the Southwest the main natural inlet and outlet of the underlying groundwater systems are mountain front recharge and riparian zone recharge/discharge areas. Mountain front recharge is the infiltration of mountain precipitation, in the form of snow or rain, into the "headwaters" of the aquifer. This typically occurs from mountain streams that carry water out onto the highly permeable sediments on the mountain pediments. Water, having thus entered the regional groundwater aquifer, flows down gradient to the center of the basin. There, in areas such as southern Arizona, the groundwater table can intersect the ground and provide base flow to streams and water for vegetation growth.

The Upper San Pedro River Basin in southeastern Arizona and northern Sonora, Mexico is an ideal area in which to investigate these poorly understood processes of regional aquifer water balance. Unlike many riparian systems that have been destroyed due to the lowering of the groundwater table by pumping, the basin has an intact perennial flow, which sustains relatively lush riparian corridor vegetation. From previous observation and modeling studies, three dominant components of basin's groundwater system have emerged. These three component fluxes -- mountain front recharge, surface water recharge, and water uptake by riparian vegetation-- are estimated to be of similar magnitude, though the error associated with these estimates has yet to be determined.

The work described in this paper is focused on the water use of a sacaton grass flood plain and a mixed grass/mesquite community. These two types of vegetation communities are often associated with riparian areas across the Southwest. Numerous observations indicate that these plants are deep rooted; thus, they have been thought to rely mainly on water taken up from the near-surface water table when they exist in riparian corridors. Current basin aquifer modeling studies often rely upon coarse, empirical estimates of riparian corridor evapotranspiration (ET), to validate their modeling calibrations. Such estimates of ET are often based on indirect measurements taken elsewhere and then extrapolated (in this case) to the San Pedro Basin using local meteorological information. In this study we employ micrometeorological techniques to measure the fluxes of water and energy in both of these communities over several seasons. Below we include a description of the field study along with some results of the research to date.

2. METHODOLOGY

Two vegetation study areas nearby Lewis Springs on the San Pedro River flood plain were chosen as the field sites for the study. One site was established in the mesquite-dominated upper portion of the floodplain. The second was established in the sacaton grass-dominated lower portion of the floodplain, between the mesquite area and the cottonwood/willow tree gallery immediately adjacent to the river (see Figure 2 in Goodrich *et al*, this issue). To determine the amount of evaporation coming from these two sites, meteorological towers were erected in 1996. These towers were equipped with a set of standard meteorological instruments to measure the air temperature, relative humidity, incoming solar radiation, air pressure, wind speed, wind direction, and precipitation. Additionally, the towers were outfitted with instruments to measure the available energy (net radiation minus ground heat flux) and Bowen ratio. With these instruments the amount of energy that is consumed at the land surface by the evaporation of water can be determined over the course of several seasons.

In order to understand possible controls on evaporation, we also monitor the state of the vadose zone soil moisture and the depth to groundwater. Campbell Scientific Inc. (CS-615) water content reflectometers were installed in a vertical transect (at .1, .25, .50, 1.0, and ~2.0 meters) into the ground to measure the soil moisture under the vegetation. Piezometers have also been installed to measure the fluctuations in the groundwater table.

3. RESULTS/DISCUSSION

For the purpose of this paper, we concentrate on presenting some preliminary results from the February to September, 1997 field measurements. From February

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until the time of writing, a near-continuous data set was compiled (20 minute averages for the meteorological data and 1 hour averages for the soil moisture). It is important to note that 1997 had (an estimate of 5 cm) less than normal rain in early spring, and the monsoon rains did not begin to fall heavily until late July -- around 3 weeks late with respect to climatology.

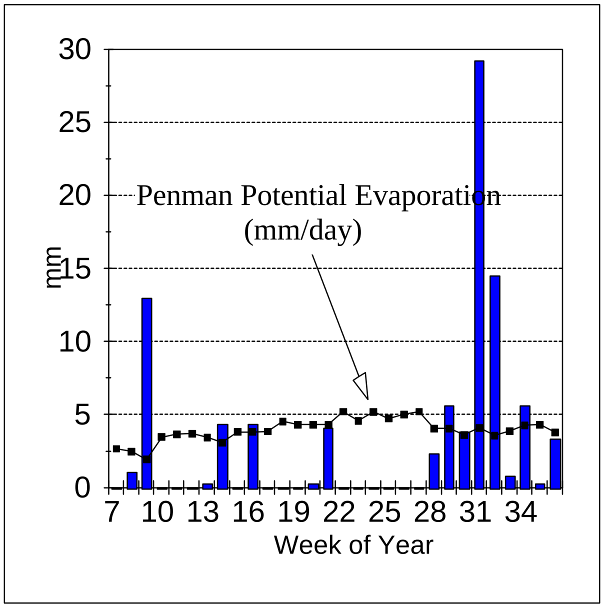

Figure 1. 1997 Total weekly precipitation and potential evaporation for grass site.

Figure 1 shows the total weekly precipitation and Penman potential evaporation (Penman, 1948) for the monitoring area. The figure shows the presence of some winter time precipitation and the onset of the North American Monsoon (week 28). The decrease in potential atmospheric demand after week 27 is a result of the decreased vapor pressure deficit and decrease in total net radiation.

To determine how precipitation influences the state of the soil moisture, Figure 2 displays the evolution of the volumetric soil moisture at the two sites. Remarkably, the only significant changes in the soil moisture appear to occur only within the top 25 cm for the grass site, and within the top 50 cm for the mesquite area. The largest and only significant change in the 10 cm-and-above soil moisture occurred during the heavier rains in early August (week 32). The difference between the sites' soil moisture status is largely due to the differences in the respective soil types. The sacaton region has less-permeable clayey soils while the mesquite site has sandy soils.

Next, we examine the results from the energy balance Bowen ratio (EBBR) system. Our primary objective was to make long-term measurements of water use for the two communities and to compare these estimates with others that have been made in similar communities. Figure 3 shows the weekly mean evaporation (along with the potential ET reproduced from Figure 1) from week 7 to 37 of 1997. The rates from the grass community confirm our observations that the grass largely remained senescent until the rains in summer. The mesquite community leafed out in May and stayed active throughout the summer months, and it showed little effect from the addition of monsoon precipitation. Interestingly, the grass evaporation began to rise at the onset of rains, though no moisture had penetrated to depth until the larger rains of week 31. Most likely the slight increase in mesquite ET at the onset of the rains is largely due to an additional contribution from bare soil evaporation rather than enhanced transpiration from the vegetation. Conversely, the data from the grassland vegetation shows that there is a large effect of precipitation on the evapotranspiration response.

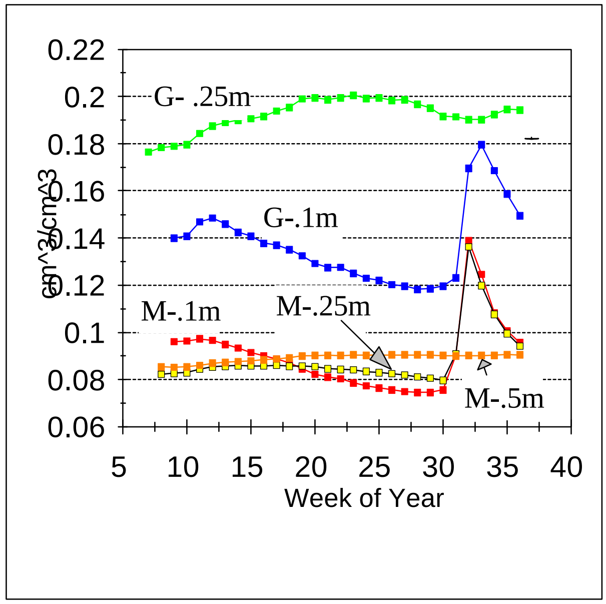

Figure 2. Mesquite (M) and Grass (G) site volumetric soil moisture for different depths.

Observations suggest that the mesquite was not water-limited in the study region; the majority of the mesquite at the study area, which is about meters 200 west of the river and has a water table about 10 meters deep, leafed out the same week as did scattered mesquite located much closer to the river and to the groundwater table (water table depth of 2-3 meters). Thus, the greening up process for the trees appears to be limited by temperature (freezing at nighttime) rather than the moisture status in the vadose zone.

On the basis of the above results, it is clear that the grassland relies primarily upon water from precipitation and does not appear to be operating as a phreatophyte over the period we recorded data. An important exception to this case seems to be those clumps of grass that were located nearest to the river (within ~10-15 meters of the bank), which we observed to be noticeably greener throughout the pre-monsoon season.

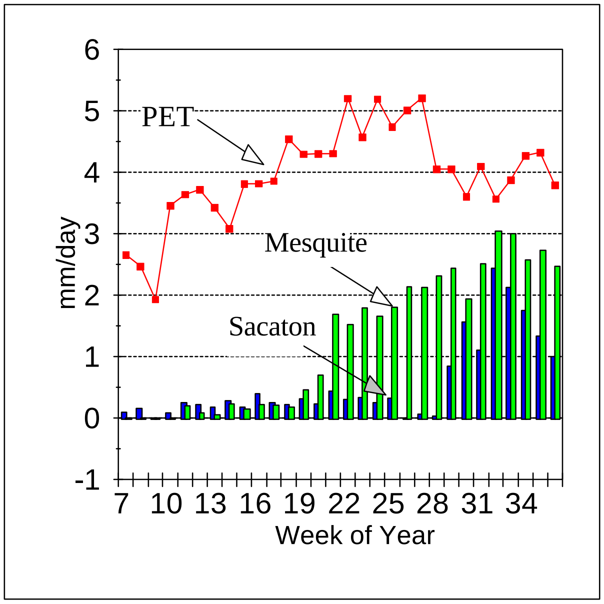

Figure 3. Mesquite and Grass site average weekly evaporation.

At the measurement site, the depth to groundwater is about 3 meters, whereas closer to river bank the groundwater is nearer to the surface. Moreover, the mesquite appear to be relying on water deep in the soil column and perhaps, from the groundwater table itself. However, the water demand is not large because piezometer water level measurements in the mesquite area showed no diurnal cycle. Thus, the mesquite demand for groundwater was not strong enough to produce a perturbation on the phreatic surface.

4. SUMMARY

This research quantifies the evaporative demand of two dominant riparian biomes. Our early results suggest that strength of the vegetation water demand (for these two vegetation types) in this area is not as high as previously estimated, and the vegetation is less of a groundwater user than previously assumed (comparisons will be made for the poster presentation). This leads us to wonder if the dominant, and perhaps only significant, groundwater consumptive use in the Upper San Pedro Basin is determined solely by the cottonwood/willow gallery that stands adjacent to the river.

4.1 *Acknowledgements*

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